II.

THE MECHANICS OF THE MOON

DEDICATED TO THE ASTRONOMERS
AND ASTROPHYSICISTS

BY

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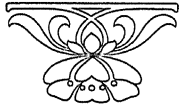
ASTRONOMY AND COSMIC PHYSIC



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Preface.

As expressed in the title, this little book is a continuation of the „Mechanic of the Moon“ written in 1905. At that time I did not think it would be necessary to write a second part, but I could not withhold from the readers the results of my latest discoveries, which are entirely unknown in the investigation of the moon.

As the insufficiency of the investigations of the moon made hitherto, it is significant that I have to write about the chief occurrences dominating the entire surface of the moon, occurrences, of which the careful reader will soon be convinced and of which, as far as I know, neither Selenologists nor Geologists have ever made a single remark.

By the following definitions many, who have hitherto been unconvinced, will come to the conclusion, that at least the principles for a successful senelogy, are based on positive experiences.

Lucerne, Villa Watt, September 1911.

The Author.

The Requirements of the Selenologist.

In order to study the finer details of the illuminated surface of the moon the telescopic observation takes first place. The interest for such detailed observations, which formerly existed, seems to have abated considerably in the last few years, to be succeeded by that for the Formation (Genesis) of the moon. To my view, this is no misfortune as a good many apparently necessary detail-questions fall away by the proper understanding of the moon's origin.

The art-works of Nasmyth and Carpenter, who made the celebrated moon reliefs, also the artistic drawings of small portions of the moon by Prof. Weinek, prove, that for such work the demands on the sight are so great, that a reliable representation of the moonformations by those means must be regarded as impossible, notwithstanding all the scientific knowledge.

Although in general the students of this science do not think they require the drawn charts of the moon, I may remark that the little atlas by Neison 1881, with

its practical position of maps and its handy form, did me such very good service, that it is almost indispensable to me.

By experiments, which I described in 1905 and still have something to say about, we have succeeded in making craters, bubbles and fortification-like formations, whereby the supposition that similar proceedings happened on the moon has become a general idea.

Prof. A. Miethe and Seegert of the Polytechnical Laboratory, Royal Technical Highschool in Berlin (Astr. Nch. B. 188, Nr. 1 and 14) have recently succeeded in making photographs of the moon and obtaining very interesting light effects by means of ultraviolett and red filter, by which means we hope at some future time, to become better acquainted with the photographic formation of the surface of the moon.

The most important aids for selenologic studies are in the first place the photographs of the moon.

I am in possession of the three most important works of this kind, they are: The Parisian Atlas of M. Loewy and P. Puiseux; the Atlas of Prof. Weinek of Prag; and the Harvard College Atlas (Cambridge, Mass.) of W. Pickering. Prof.

Weinek also kindly sent me the 19 tables of the Lick-Observatory (California).

The most convenient and well-executed Atlas was that issued by the „Société Belge d'Astronomie“ which unfortunately is no longer to be obtained.

These four works differ in size and purpose according as they are intended for general or partial selenographic study and research. The general researches demand the representation of larger complexes, and the partial ones the most possibly clear representation of single objects or groups. With regard to advantages or disadvantages of the mentioned four works the following is my opinion:

The Parisian Atlas of Loewy and Puiseux consists of 71 tables with pictures of 46×57 cm. The enlargements correspond with moon-diameters from 1,19 to 2,72 m. This atlas is a beautiful universal work conforming with all requirements for the purposes for which it is published. By the scientific, artistic and eventually historic value of the work, it would have been desirable if a means of printing had been employed, which did not lose colour and if better paper had been used for the tables. As I found the

management of such large tables and light indicators very inconvenient, for the purpose of better manipulation and protection I had the plates mounted on linen and divided into three volumes; four volumes at three fascicles would be an improvement. The opened atlas now always shows on the right side the picture and on the left the indicator belonging to it, which is exceedingly convenient. For further handiness I had the plates cut to 55×75 cm. In this manner a handsome and almost indestructible work is produced; on account of the loss of colour it is advisable to place a sheet of thin paper between the plates, as I did.

While the Parisian atlas is a universal work, the Prager atlas of Prof. Weinek is a special work for partial investigations of moon objects. The 200 tables with clichés of 25×30 cm are enlargements of 128 negatives of the Lick observatory and 72 negatives of the Parisian observatory.

The diameter of the moon is in the former 3 m., in the latter 4 m. This scale reminds one of the system of enlarging as employed in the analytical criminal photography. These pictures are for a normal eye at a distance of 2 m. and for near-

sighted eyes of 1 m. of an imposing plastic. The work is arranged systematically, so that the 200 illustrations represent 100 positions with illumination from each side. They are printed on Bristol paper in heliotype. I had them bound into five handy volumes, so that the opened book displays the same picture in the two lights. In this way, I obtained very strong plates mounted on linen with pictures on both sides; they do not require any loose paper between them and are therefore very convenient.

As a useful addition to the Weinek atlas for general and orientiering purposes must be mentioned the Pickering atlas. In this the moon is divided into 16 high fields of 102×228 mm. Each of these fields was taken in five different lights. The 80 cliché's thus obtained are executed very neatly in fine-rastered phototype. In each position the pictures A and E of the extreme phases are the most suitable for general investigation. The pictures B, C and D taken by inclined light have become of much importance in regard to the new moonphotochromes of A. Miethe and B. Seegert. The slightest trace of colour-difference in the photochrome of the moon photographs

of April 13th 1911, 10h. 24—29 min. is very clearly shown in the plates taken by inclined light, in the Pickering atlas, which makes this (not very expensive) work most valuable, as this method has only been employed on few occasions. In any case Pickering did science very good service by the systematic carrying through of his exceptional way of taking moon photographs, as their ultimate significance, as shown by the experiments of Miethe and Seegert, cannot yet be understood. In the appendix are 4 plates with the pictures showing the craters and wallpositions and also 4 additional plates in which the lakepositions are added in a very correct shading. As this atlas can be bought for £ 1. 5. — from William Wesley in London, it is in connection with the Atlas of Prof. Weinek which costs 200 Kronen a very cheap substitute for the Parisian atlas costing 420 francs, which is not too much considering its contents.

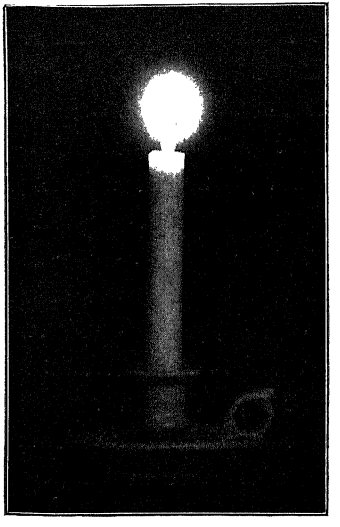
The atlas of the Lick Observatory is not a completed work, as it consists of only 19 plates with clichés of about 24×30 cm. to 29×37 cm. The pictures made in unveiled phototype correspond to a diameter of the moon of 1 m., and are partially very

well executed. With 50 plates of equal worth to the best existing, it would form a handsome and, what is most necessary for purposes of study, a handy work for general use. The question might still arise: which atlas of the moon is the most practical for universal use? Here my idea is:

An ideal work for universal use, for individual study, would to my view be about a medium between the Parisian and the Pickering atlases, conditionally that only good photographs would be employed for it. I cannot coincide with the view, that a fine raster prejudices a perfect photography and the weakness of some of the Pickering pictures cannot be attributed to that cause. Pictures so fine as those of the large Orion-fog made by Prof. Wolf 1908 are never obtainable from the moon, as all parts of it, with the exception of those marked black in Pickering's atlas and on Miethe and Seegerts photochrome appear green give rise to an outspreading brightness. For instance the eastern half of 6 A of the Pickering atlas with exception of a small portion on the south pole is perfectly sharp as proved by the appearance of the smallest craters. But on the left half of the same picture in

the Rheitacountry only faint and indistinct objects are visible notwithstanding sufficient light and shadow-effects. This fact shows that for universal use Pickering's narrow high pictures are most suitable, whereby the question might arise, if we could not follow the terminator by a fan-like arrangement of the pictures which would increase the utility of the clichés. With regard to the size of the moon 700 mm. or 870 mm. might be best which for the central part would give for 1 mm. D about 5 or 4 km. The halfmoon could be divided into 12 instead of 8 fields so that in the first case the pictures would be 135×400 mm. in the latter 170×500 mm. Two such pictures in easterly and westerly illumination might be placed side by side on one sheet, so that 24 pictures à 2 clichés would be quite sufficient for the topographical purposes. For the raysystem a single picture like that on the title-page of the Pickering atlas would be quite sufficient. For such an atlas it would be also valuable, if on the reverse of each plate the indicator for the next would be printed so that the opened book would show on the right side the picture and on the left the indicator. The more it were

possible to hinder the diffusion on the photograph, the more opportunity there would be of observing the moonstructures in the different phases of illumination. The improvement of backed (lichthoffreier) plates seems to have made great progress in the last few years,



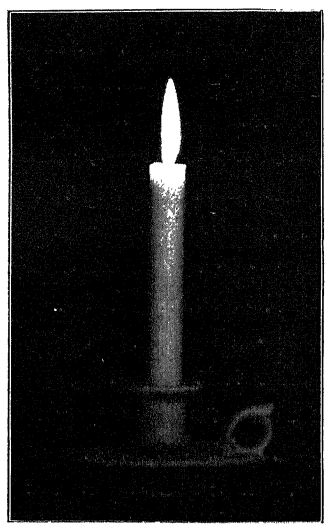
Ordinary plate

FIG. 1

therefore I show in Fig. 1 and 2 the good result of a backed-plate against an ordinary one.

This plate is a product of Dr. C. Schleussner & Co., Frankfurt a. M. and is known in commerce under the name „Inalo".

There is no doubt, that with such plates, providing the light and shadecontrasts are sufficient, better photographs of the moon can be obtained, than those shown in the A and E pictures of the Pickering atlas.



„Inalo“ plate

FIG. 2

But as the existing means answer their purpose, and as the compilation of a moon atlas requires a vast amount of patience, intelligence and time, it will probably be long, before a convenient, comprehensive and

trustworthy moonatlas suitable for universa use will be produced.

So far as the elementary knowledg of the moon is concerned, the best book in the German language on this subject ar „Der Mond" by Prof. J. Franz 1906 — an „Der Mond" by Egon Lützeler 1906 — although the works of Nasmyth, Carpenter and Neison have their own specia merits. But how scientific knowledge ca be unintentionally misapplied in writing abou Selenology, by an apparently well-informe man is exemplified by the following extract In a work of 1911 the formations of th moonsurface are given as the typical larg forms of terrestrial Pedionites, Aspites, Thc loides, Homates and Konites (!!). At th end of this chapter are the words: „Onl a study of the development of the vulcanisı of the earth and its creations can brin the solution, whether the presumed and t a certain extent proved, age-conditions c the moon, have a right to exist (?!). If thi has succeeded then it is a fact that th lunar and also the terrestrial vulcanism prc duce in certain succession certain simila buildings. This would be a further advanc in the knowledge of vulcanism."

Such terrestrial conditions are entirely excluded on the surface of the moon, as there is no more activity in the glowing liquid condition.

The Parallelism of the Surface of the Moon.

This word, used by me sometimes, has received an undreamt of signification, therefore we have to study it more fully.

There exist on the moon an optical or apparent and a real parallelism, of which the former is apparently produced by more or less parallel-running lines on the periphery of 70^0 upwards in consequence of deformation of the picture. The real parallels show themselves by furrows, which traverse the Alp- and Craterregions and which by their continuation in the same direction are very striking. All drawers of moonmaps were so affected by these appearances that the actuality remained considerably behind their imagination.

The moon has for special connaisseurs in no way a similarity to the earth, and the great moon-scientist Neison expresses himself on this point as follows: „The general aspect of the formations on the moon's

surface shows an entire dissimilarity to those on the earth."

If we enquire how it happens that some investigators try to find in certain formations of the moon a resemblance to terrestrial mountains, this error might be excused by their comprehension of the moon-charts. In fact, there has taken place on the moon a wearing away parallelism; but this was caused with fiery liquid currents, therefore the opinions of those savants must be considered erroneous with regard to mountains and craters.

The Explosion and the Deluge.

These hitherto entirely unknown subjects must bring a surprise to all those interested in moon-investigations. What makes the matter still more interesting, is the fact, that, if we do not consider the already explained formations of craters and walls, that the mythical nature of the entire moon-surface finds for the most part its explanation in the knowledge of the consequences of those events, whereby many hypothetical speculations lose their ground.

In my work of 1905 I said, that the destructions are not less interesting than

the formations of the moon-elevations and to-day I find those expressed views still surpassed. What hindered in general the investigation of the moon was the circumstance, that most inquirers had not even a sufficient idea of the glasslike formation of the stone-flux, its excessive toughness while in a heated liquid condition, its plasticity, also its brittleness when cold. From a fine glass-thread to the quantities of formations of many thousands of square-miles, on the moon-surface, there seems to exist a great difference of the actual material, and yet the wonderful capacities of both masses is nearly the same.

The forms of the moon-elevations were either structures of expanded, bladder-like mountains to be recognised by the number of bumps-similar to the Apennines, the Caucasus, the Carpathian Mountains, or the wellknown round mounds, craters and bubble-fosses. The normal run of the genesis of the moon would show us only those formations together with the enlargements and the destructions through lake-formations, — if the eruptions and the deluge had not taken place. But both these great events disfigured the face of the moon to such an extent,

that in consequence the moonexplorers or the geologists made the mistake of comparing it with terrestrial explosions and volcanic results.

Those, who study the genesis of the moon by the help of a photographic moon-atlas, must in time discover a parallelism, which is shown by the traces of destruction, but has nothing to do with the extension of the mare. The parallel inundations of many countries I noticed years ago; but recently, when by wish of Dr. Arehenhold I studied and wrote an article for the "Weltall" of the Treptow observatory, the awfully ruined condition of the Clavius induced me to further study the traces of the destruction. The continued investigation of other parts led to the surprising result, that the whole rind of the moon had been exposed to a sudden deluge of short duration. It was at once clear to me, that these masses, suddenly overwhelming the entire moonsurface, could not arise from an already existing crater, but must have been caused by an explosion of the moonsurface. The prosecution of research of the different directions of the tide resulted in the discovery, that the Altai-mountains were the place of the explosion.

The proverb „There is no rule without exception“ was here completely verified. In consequence of the stiff nature of the moon's crust, there seems no inclination towards any further eruptions in a terrestrial sense. An explosion has besides a contrary effect of contraction, therefore we have to consider the otherwise undefinable Altai-mountains as a border of the wound caused by the bursting of the moon-crust, and there is nothing to be found on the whole moon's surface to be compared with this kind of irregularity called Altai-mountains.

To the sudden discharge of the magma on this weakest part of the moon-crust, there must have been a preliminary feeble expansion; this corresponds with the elevation chart of Prof. Franz, although these elevations might have gone back somewhat after the catastrophe. A momentary discharge of such tremendous amount to one side must have caused a re-action or retirement on other parts of the moon-crust. The entire appearance of the tide shows in fact different directions, some of which flow from the Altai-mountains towards the back of the moon, while others flow direct or indirect to the lower parts of the seas Serenitatis or Im-

brium. As direction and intensity of the deluge show, the first rush must have been completed within a few hours.

While the glowing deluge and direct currents overrun all obstacles, the arrested sinter formed other means of destruction, the local deposits, which contrary to the parallelism took their direction according to local circumstances and niveau conditions. At the end of the book I have arranged in a schematical chart the defined directions of the deluge and the sintercurrents, which will enable the earnest observers to add other observations. As later on we will speak about the topographical conditions there will be many opportunities of considering the effects of the deluge, which is a most important part of selenology.

By the discovery of the deluge and its accompanying appearances, we are also enabled to particularize the events which happened previous to, during and after the deluge in the principal parts with an almost positive certainty. As existing before the deluge are to be recognised all mountain-complexes and all those round mounds and craters, the forms of which suffered considerably by the deluge and of which the interior lustre has

not attained the brightness of the formations after the deluge. The enlargement of the mare with its round forms and the destructive influence on the border-formations were appearances before the deluge. The deluge itself and the following sintercurrents caused those disfigurements which offered the chief obstacles to selenology, but which can be explained to-day without any constraint. The formations following the deluge are recognisable by their round complete forms also by the lustre of their inner parts. Most of them are bubblecraters and the little bubblefosses all belong to this category. But the large vomiting craters, perhaps with the exception of the Tycho were most probably effective before and after the deluge.

The thought whether the moon was already in danger of bursting occupied me often for a few moments but at that time I was not provided with the present helps of the Selenologist; and for the careful study of the single plates of the Parisian atlas I had not the patience, while to-day I occupy myself with this matter in bookform with pleasure. The B, C and D pictures of the Pickering atlas taken by steep-light indicate, that in the interior of the moon

existed many periods of very increased gas-pressure, in consequence of which magma was ejected through the openings of the craters to a distance of many thousands of kilometers, which caused a glittering as a distinguishing appearance after the deluge.

If we pour a liquid on the floor there will be in the centre a lake and leading from that radial running currents. This is the reason, that we observe in the close neighbourhood of the Altai-mountains, especially on the broader sides, no current streams, as in consequence of the closed run such could only be formed in far distance.

According to nature a closed run will not divide itself in single runs as long as the following masses are large enough for a compact stream. The work of destruction on the moon was for these reasons different according to the proceedings.

Every connaisseur of the moon-surface will know, that the total southsouthwest of the moon shows a thoroughly dissolving chaos and smaller new-formations, whereby the melted remains do not at all show the ruined appearance like other parts, especially like the entire northpole, where everything, except a few new-formations looks like a field

of ruins. Those, who have not yet noticed it, can easily ascertain for themselves this striking difference. The extensions of the mare cannot be taken as an example of the difference, as this tide-effect was relatively slow.

It can be proved, that the eruptions, which we call Altai-mountains end near the Piccolomini. Traces show still the possibility, that in the continuation there might have been a crack further southwest. This question has for the moment no importance, the reader may only be convinced, that in this part of the moon the disfigured face was the consequence of an explosion or a bursting of the moon-rind.

As the medium or the forcing power of the explosion in the interior of the moon could only have been liquid magma and as liquids do not expand and are incompressible, it is not probable (through the enormous toughness of the under parts of the moon-rind) that crevices broad enough for our observation could have been formed. The expanding properties of the lower-lying gases showed their after-effect by irregular currents following the deluge. By the picture of Miethe and Seegert which corresponds

very well with that of Pickering can be convincingly proved, that in later time a second deluge took place, which was less intensive than the first. The first passing-over from the tide to the direct current shows itself in the "mouthcorners", the most striking fracture formed by the Altai-mountains. In the south are several currents which flow close to the Piccolomini and in the north the same is the case in the neighbourhood ot Kant.

As far as the material at my disposal allowed, I have shown on the map by red lines the direct directions of the currents, because these currents are the best indicators for finding the place where the sudden moon deluge commenced. These are for the most part those currents, which in their rapid course without regard to obstacles took a definite provable direction.

The clearest part of the deluge is naturally the middle part of the moon, about between Aristullus and Purbach, or Sabine and Laland, there, almost everything was totally ruined as the complete formations did not exist till later on. In the western part peculiar grotesque forms are found in hollowed-out borders of the Mare Crisium

(Fig. 9), but it must be admitted, that these appearances are likely to lead the Geologist to wrong suppositions. Looking at these furrows and elevations we are disposed to believe, that they are valleys and mountains of terrestrial nature; while in fact all elevations, not belonging to craters and ramparts, which we consider as mountains, are only swollen-up bulk full of bladders, of which the foot of the Alps, or still better the Sinus Iridum (Fig. 10), form typical remainders of the slightly destroyed mountains.

As in the West so likewise on the Southpol and towards South-east many currents have passed our moonhalf and taken their way to the other side of the moon, not visible to us. The current was very destructive in the South-east, in the directions Stoeffler — Mare Nubium and Maginus — Mare Humorum. It is interesting to remark, how a considerable part of the different currents flowed in the direction of, what Prof. Franz designates, the Low-lands.

It is not necessary now to enter into detail-questions. We shall have many further

opportunities, to show by means of pictures taken from the Parisian atlas, interesting consequential phenomena of the deluge.

The Light Reflexions of the Moon.

I take it for granted, that the second picture of the moon, which Prof. A. Miethe and B. Seegert published in the Astronomical News, volume 188 Nr. 22, is accessible to all my readers, and that therefore they have a knowledge of the means, by which ray-separating copies of moon photographs can be made by ultraviolet- and red-filter. This success surprised me in the middle of the present work and was so far welcome, as I knew for certain, that it is only few moon-explorers, who are enabled to speak with any degree of probability, about the significance of those light effects with regard to genetical relations, whereby my experiences in the matter of melting-currents proved very useful.

In the first place I wish to remark, that the light intensities prove a correctness of the picture, as with regard to the light division they are an exact mirror-picture of the steep-light B, C, D-pictures of the

Pickering atlas, in so far as the difference of size and diversity of this atlas allow such a comparison to be made. The Pickering atlas is much richer in details, on account of the large number of pictures, as each region was photographed by morning-, noon-, afternoon- and evening-light. With the new moon-picture this detailrichness seems to be nearly sufficient for learning the signification of the colour-differences with regard to genetic, so that improved or enlarged pictures will not very much alter the general impression.

For the moon-pictures in colour-printing of Miethe and Seegert the choice of colours was left open to them, therefore these colours have in no respect anything to do with the actual colours of the moon. For our definition we can use the names of these colours without risk of being misunderstood. The colours to be distinguished are the following: white, red, green, white on red, white on green, red on white and red on green. Green on white or red cannot appear for genetical reasons.

Green signifies the original condition of the first cooling period. The substance is dark, and appears black in the Pickering

atlas. In the pictures B, C, D of this atlas, which are all taken by acclivity illumination, it is visible that the rampartcrowns of many craters, which have been affected by the deluge, glitter like fresh magma; this can also often be noticed on the craters of Mare Foecunditatis. This leads to a question, to which an answer cannot yet be given. Supposing that the grazed glittering rampartcrown shows the material of the interior rampart, then the entire moon must have been oxidized on the surface in consequence of exterior influences, and this in such a manner, that e. g. neither the strong overflows in Mare Tranquillitatis nor in the large Mares Nubium and Procellarum could have scratched or inundated these parts. Supposing the reverse, that this glitter or brightness of these grazings has its origin in welded-together deposits of deluge-magma, that would mean, that at the time of the passing-over from the boiling to the stiff consistency of the moon there was as yet no clear magma, and that such was only separated under the stiff cover by a relative subsidence.

It seems to be excluded, that at the time of the passing-over from the boiling

to the stiff condition there existed clear magma, therefore the green ground can hardly be anything else than a mixture of many deposits.

It may be possible at some future time by much enlarged partial photographs after Miethe and Seegert to obtain enlightenment affecting this question. There are few parts where this green of the primitive condition was not later on covered with red or white magma. But it is visible, that the influence of the temperature was great, as the substance of the deluge cooled down in proportion to the distance travelled, so that the lower parts of the little Mare Nectaris and Humorum, also the entrances of Mare Foecunditatis and Nubium show the results of a higher temperature by a deeper colour. In the Mare Crisium it is clearly to be seen, that the obstructed passage of the mass caused magma to be deposited there; the same is the case at the Grimaldi. With regard to Mare Serenitatis and Imbrium they can easily be recognised as the low-lying collecting basins of sinter-currents. Near the Aristarch, according to the atlas of Prof. Weinek plate 3, the remains of a rampartplain are visible, inside of which is the magma of W o o d's spot.

An interesting example of the darkened fresh magma is the following: The crater Proclus in front of the Mare Crisium vomited magma after the deluge, which is distinctly visible on the cover of this mareplain. Therefore a second deluge must later on have taken place, causing an overflow from the south, which extended as far as the crater, whereby the underlying part became noticeably darker coloured. In any case there was a considerable time-difference between the first and second deluge.

Judging from the photochrome of the extended diffused complex of the southern part of the moon, that reaches to the centre, this forms, according to the coloured picture as well as to Pickerings atlas, further proof, that the deluge must have begun at this place. In consequence of the glittering the colour of this magma is weakened, but is sufficient to recognise that these masses perhaps in connection with metals, have by explosion been thrown from the deeper parts to the surface.

In contradistinction to the apparently metallic magma, all the upper layers of this bulk, which form the bubbled mountain-or island complexes, are a purified spec. lighter

magma of the kind like fluid glass. So we find along the entire border of the Mare Imbrium the remains of a swollen mass, which appears colourless like the cast-out magma of Autolycus and Aristillus, while magma, which was carried from the Manilius country over the Apennines by the deluge shows distinctly red. We can therefore take it for granted that the brilliancy of the cast-out and expanded magma proceeds not only from the outspread rays of light, but that the matter itself is of a greater brightness.

Although the colour-picture conceals from us most of the moon-details in consequence of its representation of larger masses, we must agree, that it affords many advantages to selenology and that it will become a guide for the Albedo-investigations. The time is not far distant, when we shall hear of moon-studies in petrographical direction. The production of much enlarged detail-pictures by filter copies with phase-exposure and exclusion of radiation, seems to me a thankful problem for the future.

The Mountains.

Besides the masses of craters of all kinds, which in consequence of their origin

can be considered homogeneous, there exist on the moon protuberances full of bubbles, which are called mountains. The surface-structure of those swollen bumps caused by the expulsion at the same time of magma and gases are found in the best preservation on the border of the Sinus Iridium and the surroundings of the large cross-valley.

As shown by Figs. 3—5 I made with liquid printing metal on a little wet board with a lath bordering by means of steam some swellings, which, with regard to genetic may in some particulars be compared with the above mentioned mountains. As seen on some opened bubbles the amount of material is very small. The pictures are made to show, how such bubbles have to be considered without regard to the material. Fig. 6 shows that beneath these bubbles are hollow spaces, although the metallic glittering of these cavities causes them to appear as elevations on the picture.

As regards the tough glass-or stonelike fluid on the moon the relation of mass to hollow space is doubtless very different, so that with the six times lower specific gravity, the thickness of the bubble-lids can be several hundred meters. On the Mare Crisium, the

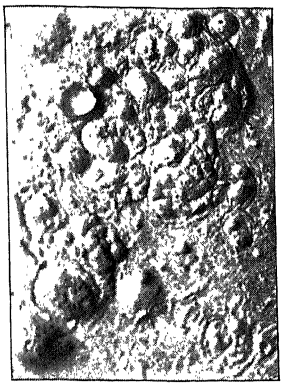


FIG. 3

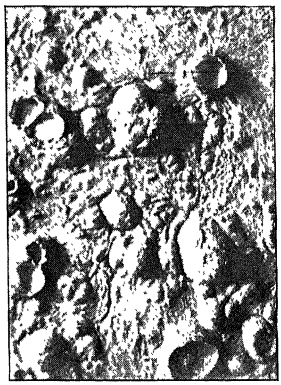


FIG. 4

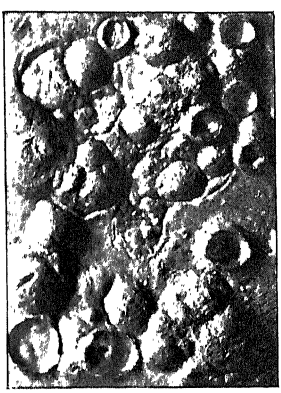


FIG. 5.

FIG. 6

Caucasus and on the Apennines it can be shown, that these masses could not form such resistance to the deluge as the homogeneous formations.

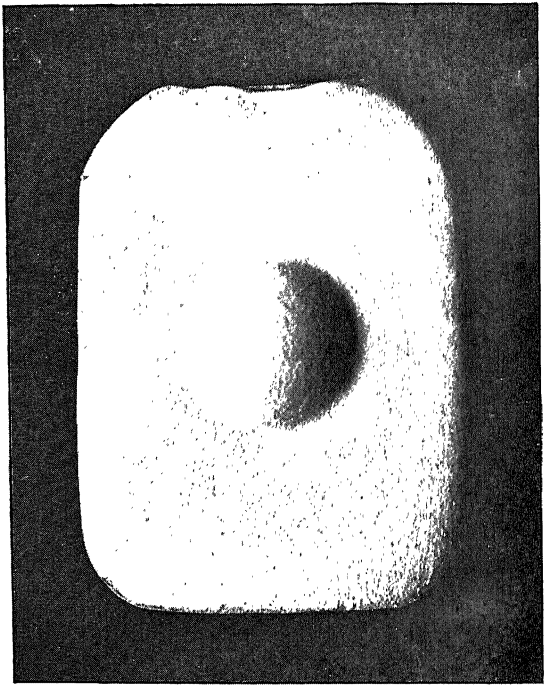


FIG. 7

Fig. 7 shows a blown glass bubble covered with oil-paint and sprinkled with Vienna chalk, which as well as Fig. 8 I

produced with a (by myself) specially arranged apparatus. It was necessary to introduce a fine pipe into the lower part of the glass, otherwise the air-pressure would have caused the flowing glass to run aside. The sup-

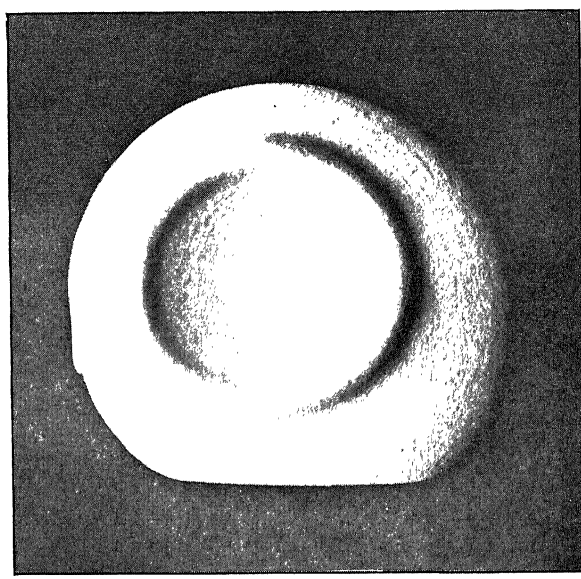


FIG. 8.

position, that for lunar-genetic experiments nearly analogous masses should be used, is an error, as those masses with their exceedingly plastic conditions are too inert or not liquid enough. As shown in Fig. 8, is was

not intended to burst the lid of the bubble, but simply to sink it into the crater; this must have happened thousands of times on the moon, when the gases condensed or could find another escape. On this point I have already been well understood in my work of 1905, so that it is not necessary to say more here, only to refer the reader to that book.

From the Wrinkle to the Slit.

In studying the moon-wrinkles the explorer encounters different typical appearances: For the first, these wrinkles are only to be found in flat countries of the moon's surface; for the second, these formations are never suddenly interrupted in their length and in the third place their height is without exception so insignificant, that for their closer observation it is necessary to make use of the illuminating effects of the terminator.

Many appearances on the moon show, that the upper layers of the moon-rind are of a glass-like substance, this is proved by their toughness and plasticity at high temperature. The slight elevation of the wrinkles and their infrequent appearance on the mare-

surfaces show, that the genetic cause of this cannot be a contraction of the moon in the sense of the terrestrial wrinkles and mountain formations. The terrestrial wrinkle-mountain is a contraction of cooled masses in consequence of the diminution of the temperature in the interior of the earth. On the moon the cause of the wrinkle-formation was the opposite, which explains the insignificance of the ground-elevations, as the formation of the wrinkles could only be a result of ulterior groundheating by the magma of the deluge or the extension of the mare. From the condition of wrinkle to that of crevice we have to distinguish three different stages, as the stiff masses of the moon-rind could not remain insensible to the different intensities of the magma-temperature and -quantity. The Mare Imbrium, Serenitatis and Humorum have by their concentration of magma increased the temperature of the ground, so that wrinkles were formed by the thermal expansion of the surface.

The Oceanus Procellarum as well as the Mare Nubium, Tranquillitatis, Nectaris, Foecunditatis and Crisium are all more overflowed countries, and all show wrinkles. Neutral countries, without formation of wrink-

les are those rich in craters and consequently conrplexes or surfaces full of bubbles, where the increase of temperature is equalised by zones of thermal decrease. The overflows were also a cause of the straining-rents and the condition of some of these shows with certainty, that an overflow took place more than once. The most interesting country showing the extreme gradations from wrinkle to split caused by the deluge, is that surrounding the Mare Humorum. In the Southwest, before the flood reached the Marebasin, we find three circular rents; in the basin, where the masses could collect, wrinkles are amassed, and on the northeastern border there are again different rents. The southern entrance of the Mare Nubium also shows enormous rents. Considering further the rents and furrows near Ariadaeus and Hyginus, we come to the conclusion, that in these parts, the slightness of the overflow and the small quantity of magma-deposit, was doubtless the cause of these strain-rents.

My experiences in the subject of thermal decrease, caused me to declare in 1905, that the rents from straining and decrease could not possibly be seen from the earth, unless a vast amount of torn masses had

been precipitated. In December of the same year I received a letter from the moon-explorer Fauth, in which he had drawn two profiles, one of them showing a river-bed threequarters full, the other showing the same quite empty, the first of these profiles showed a section through the moon-furrows according to his idea, the other according to mine. It can be proved by the moon-picture of Miethe and Seegert as well as by the Pickering atlas, that more than one deluge took place and it is an almost self-evident result, that the scarp-precipices which I described, must have happened, and that those ravines are nearly filled with magma, as correctly observed by Fauth. The regularity which those furrows show in the illumination of the moon-photography makes it evident that the furrows are filled-up with deluge magma and that the deep parts were caused by contraction, as can be observed by casting a mixture of cement. It is probable, that the deluge damaged in some manner the sharp corners of the furrows, therefore they are still better visible to us.

Secondary Questions.

It lays in the nature of the genetic moon investigations, that an endeavour should be made to discover a satisfactory explanation of all appearances, which are out of the regular course. Although this endeavour must be recognised, the study of secondary matters often causes a doubt of the correctness of the principal part to arise, while they ought rather to settle the principal questions. We will now take into consideration four of these secondary questions, which at different times have found wrong explanations. These are: the dislocation of the rays, the polygonal forms, the formulae for the diameter and depths of the formations and the seniority of these formations.

The rays are masses of vomited magma, but by many persons the different appearances of their dislocation, that means their deviation from the radial direction, have caused doubts to arise respecting the principal question. One of the most striking examples of this kind is the ray directed to South, which forms a tangent to the easterly part of the Tycho. On the other hand the Tychorays are distinguished by their relative

straight direction, while the rays of Copernicus and Kepler are violently dislocated.

The principal cause of the lineformation and dislocation exists in the wonderful toughness of the matter itself. The dark Tycho-rosette proves that no vertical expulsion has taken place on the Tycho, while on the contrary the earthly volcanos throw their material round the craters. In consequence of cohesion the exceedingly tough magma ray was in all cases drawn to one side. As soon as these cohesive resistances gave the ray not a radial, but a slanting or even a spiral direction, the dislocation from the radial direction was a necessary consequence. In this respect the ray-sytem of the Copernicus caused by violent dislocation forms a very striking and interesting spectacle. With regard to the question, whether wind could have exercised such a considerable influence on the dislocation, it may be said, that such a leading-off of the rays could not have had an effect of so great importance, as is visible from the earth.

As the comprehension of the deluge has explained many difficulties, so is also the case with regard to the polygonal forms of crater and moundplains, while each separate-

elevation could only be of a nearly-round form. Therefore when a single-formation has taken another shape, the cause must be a genetical obstacle or a destructive deformation by the deluge. The most striking appearance of this kind is the moundplain of the Ptolemaeus in Fig. 16, which shows clearly, that the deluge gave to the damruins the polygonal form with six corners. The flood led the sides parallel, while the part lower down, which did not run-over, was led in an angle of 60^0 towards the centre. On the upper part a deformation of the outer slope of the Alphons also took place through the currents, so that the Ptolemaeus actually has the appearance of a hexagon. But still such exceptions give no right to question the circular form for the Genetic of the single formations of the moon.

But the Ptolemaeus is also in other respects a remarkable object. It shows, what a mistake is made, when from its depth, which might have been twice as great before the deluge, formula are derived for the width and depth of craters and ramparts in general.

In my work of 1905 I said that the differences in size of the formations were

caused by the different temperatures and by the amount of gas and magma. The opinion has also been expressed, that the large round moon-formations were the last creations, and that therefore the earth at some future time may also show such large elevations, as the moon is unquestionably older than the earth.

With regard to the earth this supposition is incorrect and therefore the question may be considered as settled; but with regard to the moon just the contrary is correct. The study of the craters and the mounds or ramparts show, that the largest formations are the oldest. Besides it must be considered as a matter of course, that the expanding gases caused larger formations while the masses were warm, than those, which later on were formed, when they were cooling. In general it can be said, that the decrease of size of the ramparts during their formation is proportional to the increasing coolness. Therefore it results, as I said before, that the different names of the genetic round-forms have more relation to their size, than to their age, as they all resulted more or less from the same cause.

Comparing the age of the moon with that af the earth, the relation of the sun

to the planets, also of the large planets to their moons, show that the moon with $^1/_{87}$ part of the earthmass had the same aspect as to-day, while the earth was still a little sun. The at the present time, still clear, glittering condition of the ray-system shows, that, through all the enormous time-intervals they were not spoilt by any influence such as oxidation or dust; this seems to support the view, that there is no moon-atmosphere, and therefore the idea that nothing exists in the universe is not without truth.

Concerning the Topography of the Moon.

In the following pages I wish to talk about twelve pictures taken from the Parisian Moonatlas, which have a remarkable importance with regard to genetic.

Although the small size of the book does not allow very large pictures, in the course of the discussion it will be found that they will have an instructive effect on genetical studies.

Fig. 9. The Mare Crisium is, with exception of the Grimaldi, the only one of the known typical mares, which with its roundish extension has remained isolated,

till the deluge reduced to ruins its borders consisting of expanded magma. Although

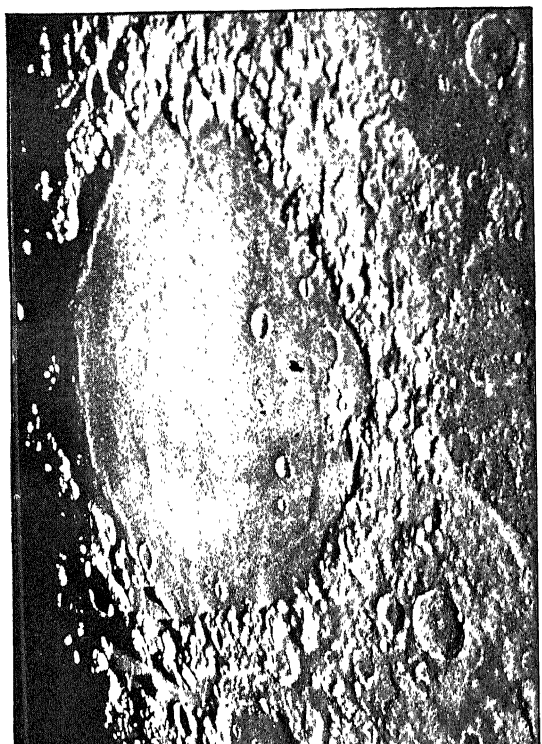


FIG. 9

this condition is not contrary to the fact, that all elevations on the moon were caused through the rising of red-hot gas and magma,

the aspect of these mareborders requires an explanation of their irregular forms and such can only be given by the acceptation of the deluge. The resistance offered was very unequal, it could not be expected otherwise on account of the masses full of bubbles. A principal current ran from the middle of the mare Foecunditatis, then through the mare Crisium where, most likely, as shown by the photochrome, in consequence of a delay in the unhindered flow some magma remained behind. It is very interesting to notice how clearly this is demonstrated by the moon-picture of Miethe and Seegert and the Pickering atlas 3 C. With regard to the wrinkles it is shown, that they do not follow the borders so much as the direction of the currents, and that they extend from the southern to the northern valleys.

Fig. 10. The Sinus Iridum, which formerly (like the Grimaldi) was a little sea, came in connection with the Mare Imbrium. There are only two countries where the bubbly blown-up masses can be seen with such clearness. The rushing deluge masses from the Mare Imbrium, judging from the photochrome, ceased at the Sinus Iridum and also before the Plato-plain. If the over $^{3}/_{5}$

of the circumference of the boundary of the Mare Imbrium and also the total enclosure

FIG. 10

of the Mare Crisium by the swollen masses are considered, it seems, that between these masses and the formation of the mare a

causal connection existed just as the preservation of the heat caused the formation of the mare and favoured their extension.

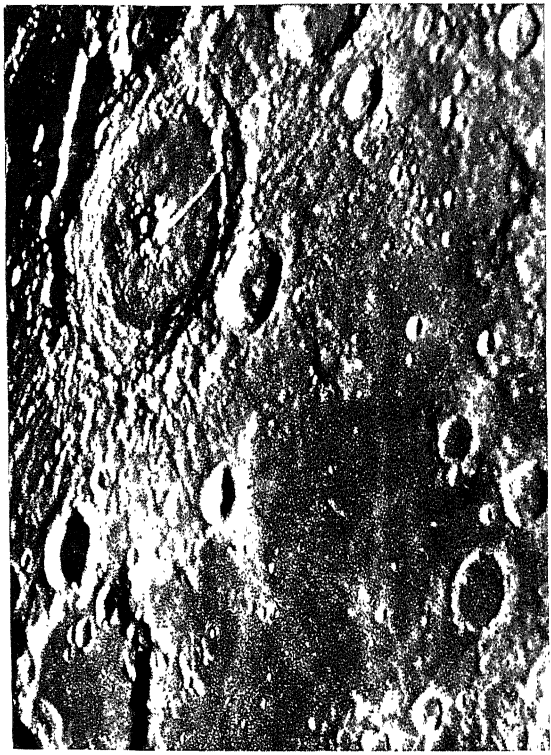


FIG. 11

Fig. 11 shows the interesting genetic formation of the Petavius. There is no

other object where the interrupted activity is shown so clearly, and in which the later infusion seems to be imbedded like a cracked plate. The continual trickling through gave the surface a convex form and in the middle is a number of attempted out-rushings, suppressed by the cooling. Since the discovery of the deluge, it is clear to me, how in the plain of the Piccolomini the flow of the magma flooded the mound in a northwesterly direction, as is shown in this picture very clearly.

Fig. 12. Above is the Clavius, full of ruins, below the new formation of the Tycho. In the whole South of the moon there is no large object spared by the deluge. All here visible (not ruin-like formations) were formed after the deluge and are of insignificant size. Although at the Clavius the currents show clearly, the principal effect of the destruction lays in the melting in consequence of the high temperature, in contradistinction to the isolated ruins of the Northpole.

Fig. 13. Here we find a current leading downwards along the Altai-mountains, while on the left are signs of a northwesterly overflow. Catharina and Cyrillus

were changed into basins, while Theophilus was more able to divide the current. As

FIG. 12

the photochrome shows the Mare Nectaris and the partly molten Fracastor existed already before the deluge. The extent of

the Altai-mountains seems to have attained at least the height of the Cyrillus.

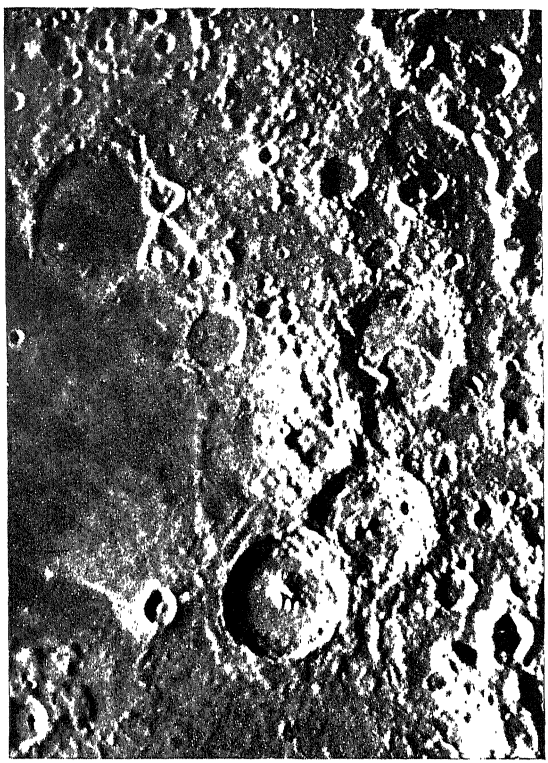


FIG. 13

Fig. 14. The Copernicus was a strongly erupting crater with, contrary to the Tycho, a wildly scattered ray-system. With all

possible elevating powers the magma was expelled and thrown over the outer slopes,

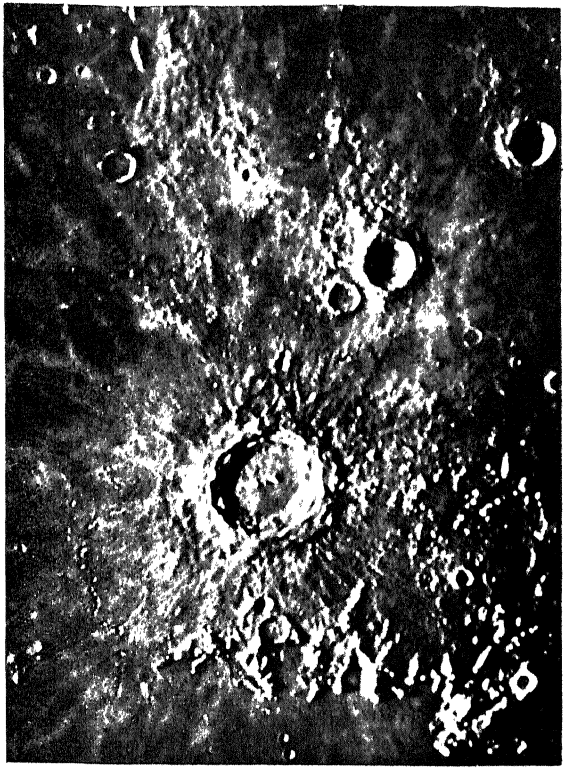


FIG. 14

so that large furrows like little mountain-valleys were formed. And yet on the western side the characteristic melting caused by a

northerly current of the deluge is not missing, while in the continuation a remnant of the Carpathian was also carried with it. This picture displays wildness and power to an extent, that no artist could possibly better represent on canvas.

Figur 15. The Triesnecker district is easily known by the large long furrows which run through the connecting valley between the Sinus Medii and the Mare Vaporum. The furrows show, that the valley itself was over-run by a deluge breaking through from the Altai-mountains. The Triesnecker, Horrocks and Ukert in addition to some smaller craters are new, nearly all other parts were reduced to ruins. The direction of the deluge can be traced everywhere. From a genetical point of view the Hyginus furrow belongs rather to the Triesnecker valley than to the Mare Vaporum.

Fig. 16 is a continuation of the preceding. The craters Alpetragius, Herschel, Laland, Mösting and some smaller ones were formed after the deluge; this can be recognised very easily. All other parts are partially destroyed as in the former picture. Keeping the direction of the flood in view, we have not long to study how the mounds

of the Ptolemaeus and Alphons
circular formation and became shap

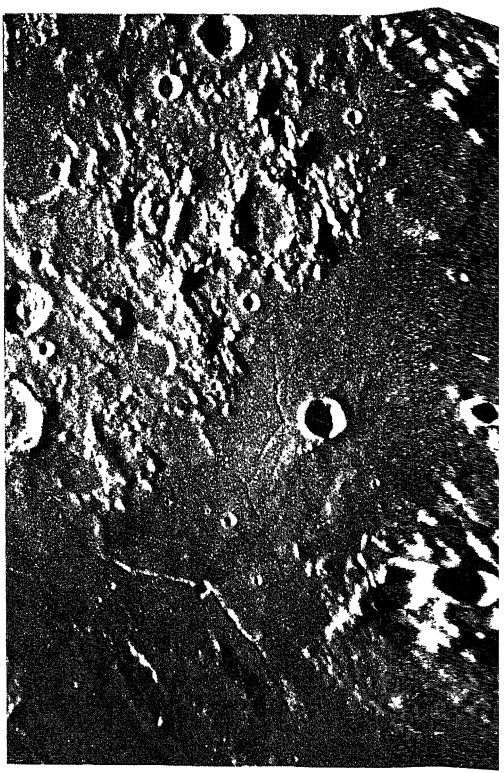


FIG. 15

bling hexagons. The supposition of
type of polygonal forms is from
reasons to be rejected with all pos

Fig. 17. While the two former pictures showed the destructions caused by

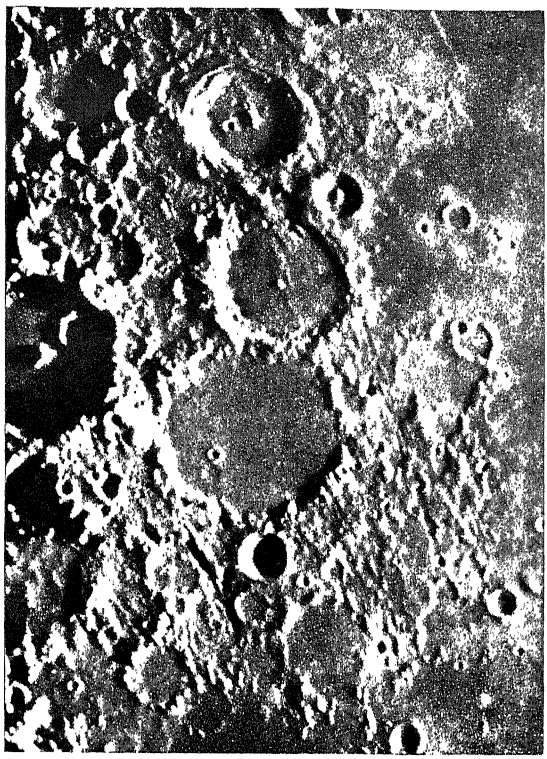


FIG. 16

easterly deluge the partial destruction and furrowing of the Caucasus belong to the deluge current, which took a northerly direc-

tion from the Altai-mountains. From the structure of the Caucasus it can be seen at

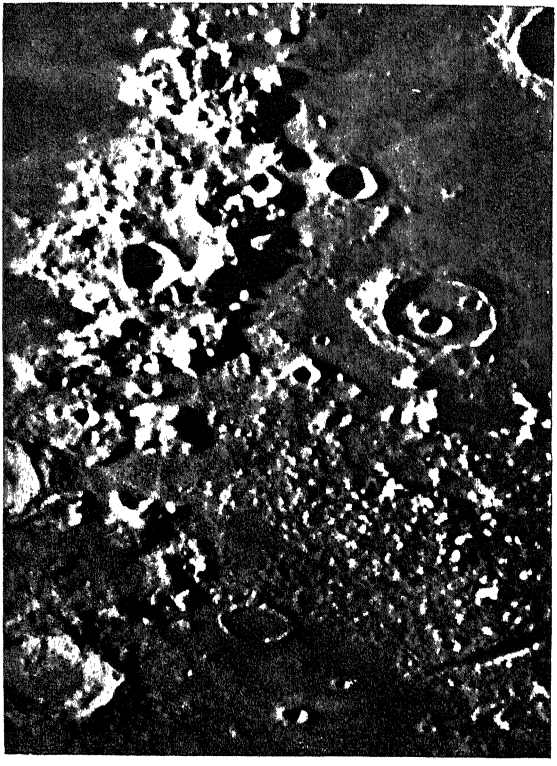


FIG. 17

once, that it is not homogeneous but a sponge-like mass with many bubbles. It is not excluded, that channels run through the

mass. Between the Cassini and the crossing valley is a swollen-up mass which throughout is covered with bumps, it is similar to the Sinus Iridum. The real genetic boundary of the Mare Imbrium runs in the direction Plato-Cassini-Caucasus-Apennines-Eratostenes.

Fig. 18. The Apennines and the large craterformations in front of them belong to the most interesting parts of the moon-surface. The extension of the Mare Imbrium undermined, apparently without much resistance, the expanded masses of the Apennines, which naturally were less cooled in the interior. For a re-melting of the broken-down rocks the temperature of the mareflow was no longer sufficient. The deluge, also here furrowed over the surface of the mountains as in the Caucasus. These furrows continue through the fallen masses; the Archimedes received through a southern breach a part of the flow, which forms its flat ground.

The surroundings of Autolycus are erroneously called Palus nebularum, but the photochrome and the Pickering atlas show clearly, that it can only be a part of the Mare Imbrium cast over from the Autolycus.

Fig. 19. This picture of rays has to be looked at from the right side. The rays

are in comparison to the Tycho more scattered, less regular and less straight-lined, also

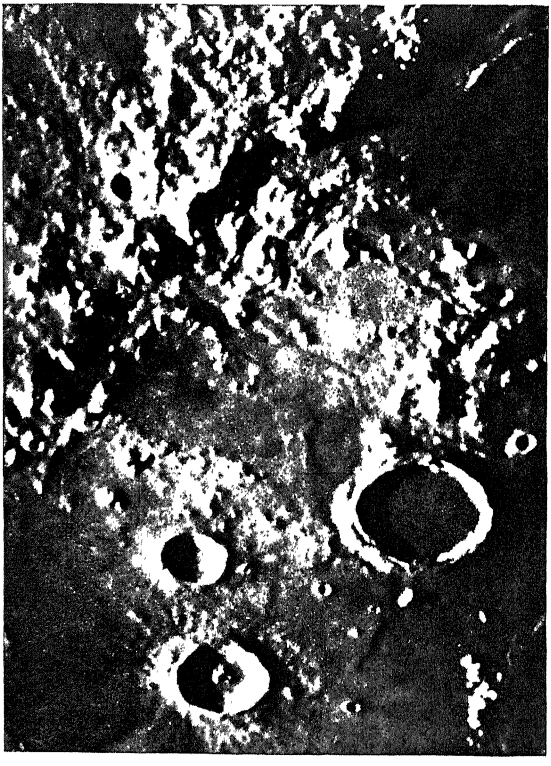


FIG. 18

the well-known dark rosette is entirely missing. The difference in this striking appearance results in the first place from the differ-

ence of time. Most of the known ray-systems originated after the deluge, otherwise they would have been destroyed like

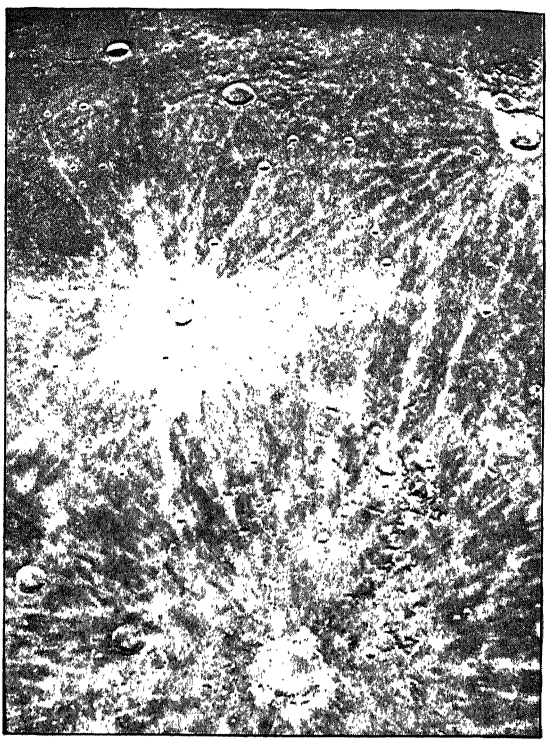


FIG. 19

a portion of the inferior ray-system of the Palus, which was inundated by an after-deluge. This is best seen, as a mysterious

appearance, on the photochrome, also on each moon-atlas. The magma, with exception of the Tychorays, was more liquid and consequently more flexible, so that the masses were thrown in all directions, even upwards, in consequence of the gases escaping with the rays, therefore could not possibly form dark rosettes as on the Tycho. The wildness of this stormy proceeding can easily be recognised by comparing it with the other ray-systems. The magma was stiffer and more consistent at the later out-break of the Tycho, whereby the throwing distance was enlarged, but in consequence of the cohesion vertical magma ruptures and therefore the flooding of the outer-walls were impossible, thus causing the hollowing out of the uncovered dark Tycho-rosette.

Fig. 20. As already remarked the ruined condition of the South- and Northpole-countries is quite different, although both regions are rich in details. On the Northpole all is covered with ruins and breaches and in consequence of relative trifling ground-heat is covered with a few small new craters. The moundplains are entirely filled with magma and the niveau seems to be very regular as the Meton, consisting of six de-

stroyed ramparts, forms a single ground-surface. The conditions on the Northpole confirm also, that it is impossible to com-

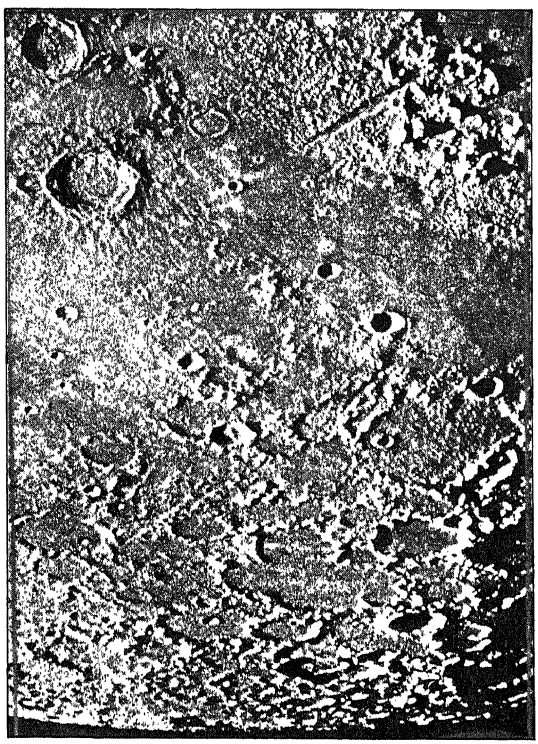


FIG. 20

pose any useful formula of the depth and size of ramparts and craters. Judging from the exterior view of the Aristoteles it is to

be concluded, that the quantity of magma, thrown out from this crater, was considerable, and formed a good part of the Lagunes of the Northpole. It seems that the name of "Mound"- or "Rampart-plain" is better to define in the sense that only large craters with flat ground-elevations, caused by the exterior bursting-in of the tide, should be called „mound-plains". Contrary to this definition, we see on the borders as well as on the ground of the Aristoteles, that the latter completely retained the character of a crater, it is nearly the same formation as the Copernicus.

The Scarcity of Water and Air.

Those, who thoroughly study the genesis of the moon, will find, that, in consequence of continual cooling of the moon-surface the time must come when a large mass of enormous gasbubbles could no longer break through the exterior moon-rind, so that many gasenclosures can be recognised by the number of bubbles on the surface. There can further hardly be a doubt that in addition to the telescopic visible cracks in the glass-like, forcibly-cooled moon-rind there

must have been, reaching to many kilometers in the depth, a great number of smaller crevices so that the hollow parts formed by the bubbles were connected with the surface in different directions. Those who have to do with molten glass, its treatment and its artificial cooling, can speak from experience about these processes. The quantity of water on the moon, 87 times smaller than that on the earth, has found plenty of room in the hollow spaces under its surface, otherwise there would be steam and clouds which could not possibly escape observation during the fortnightly illumination. This condition below the moon's surface is therefore in strict contrariety to that on our earth, where in considerable depths there are no cavities, and in lesser depth some hollow spaces are found but never of bubble-like nature, as such could not possibly have occurred in the sediment-deposits nor in the eruptive masses thrown out from the interior. It is peculiar, that there are still some savants, who endeavour to find proofs of analogy between moon and earth, while these planets in relation to masses, life-duration and building are quite different, the same is not less evident with regard to the internal

and external amount of water on both. It might therefore be nearly correct, if, with regard to the water-question we say: "With a proper comprehension of the genesis of the moon the solution of the water-question is self-evident."

Before we enter into the atmospheric subject of the moon, we will consult the rotation of Venus. In the year 1889 Schiaparelli surprised the astronomers by the information, that according to his eight years observations Mercury turned on its axis in 88 days and at the same time completed a revolution round the sun. Later on he said, that this synchronous condition, where the turning on the axis and the synodic revolution fall together as on the earth's moon and Mercury also existed with respect to Venus, and took place in 225 days. This belief was at that time shared by Perrotin, Terby, Vogel, Holden, Lowell and others. At the present time it seems, that the greater part of the astronomers like most of the elder savants of the 19th century attribute to Venus a rotation in 23,5 hours.

In this year's "Weltall" part 8 Dr. Felix Linke published an article on „the moon systems of the earth and the planets".

ith regard to the rotation of Venus, the riter comes to the simple conclusion, that enus like the earth must rotate, as it has considerable atmosphere, which otherwise consequence of the great cold (250°) ould become entirely liquid on the night- de and also cause the liquidation of the mosphere circulating from the front-side. his most probably correct supposition permits ie almost certain conclusion, that, long efore the gradual slackening reached the rced rotation, the weak atmosphere on the oon found its way as a condensed product ito its interior through the many crevices n its surface as the moon-rind is covered ith such cracks. On account of the extreme mperature and want of water no vegetation f any kind can exist on the moon, while n the other hand it seems more than pos- ible, that the origin and development of all egetable and animal life was a necessary onsequence of the influence of water, or in ther words, that an organic development s impossible without dampness and an equa- ised temperature.

The forced Circulation of the Moon.

The synchronism, that means the exact falling together of the synodic circulation with the moon's turning on its axis, is generally, but incorrectly, called liberation, this the reason, why, for the purpose of marking the sense of dependence, we employ the technical term "Forced Circulation".

This forced circulation is, that the moon in consequence of gravitation not only to the surface-law in general, but also with regard to the axialrotation is in the power of the earth, so that it can be said: the moon is turned round its centre of gravity by the earth.

In 1856 Hansen placed the moon's centre of gravity 57 km. behind the actual centre. It is almost a matter of course, that the cause of a slower rotation of the moon was sought in a kind of tide-effect as at the time of the genesis the rotation took only 2—4 hours. By the acceptance of such a cause as external tide-effect two things have evidently not been taken into consideration. The first is, that the moon's surface consists of a fusible matter, of which

the toughness and slow plastic alterations towards the period of hardening few persons can form an idea. If a continuous tide-effect had existed at the commencement of the surface-condensation, the moon would show round the equator a continuous band with meridional rents in consequence of expansion, also pads in consequence of congestion. Prof. Franz made an attempt to designate a genetic equator (report of the Royal Prussian Academy of Science 1906 XXXIV). The result was, that the mares form a circle round a pole which lays between Moretus Gruemberger and Klapprot. Although a permanent deformation of the moon by outside tide-effects must be considered impossible, it is on the other hand improbable, that through the unequal elastic requirements of the moon-rind, the mare-formation on the equator was assisted by gravitation, as the mare certainly existed before the deluge.

A second circumstance, which evidently has not found sufficient notice, is, that the question of the homogenity of the body of the moon was little or not at all considered, otherwise it would not have been possible, to adhere so long to its deformation in form of a three-axial ellipsoid. After Prof. Franz

and others have ascertained, that the lengthening of the axis towards the earth can only be one thousandth-part of the radius, where as the niveau-differences alone are more than the double, therefore we may well renounce the ellipsoid-hypothesis.

By the genesis of the moon it can be proved without any doubt, that the moon completed its exterior activity under the influence of all three aggregate-conditions; this is also confirmed by the specific density as it is generally accepted, that the material of the moon does not differ much from that of the earth. As the unstable liquid and gaseous masses existing in the interior of the moon must have been very different with regard to their weight, it seems, that in consequence of the centrifugal power, the heavy liquid masses were forced more to the exterior of the moon's orbit and have acted as a kind of brake, which brought the course of the moon quite gently to a nearly absolute forced-circulation. As by these means the centre of gravity became shifted towards the exterior through the one-sided deposition of the masses the nearly perfect ball-shape of the moon forms the pendulum with direction towards the earth, which

formerly by force of logic was taken as an exterior deformation of the spherical form.

The fate of the liberation or forced circulation proceeding from the forced cooling seems not only to have affected all the moons but extended even to Mercury; but here the greater mass and the nearness to the sun were of special importance in the retardation of condensation, which is shown by the great specific density, while the considerably larger mass of Mars, which is four times as far from the sun, is not $^2/_3$ of Mercury's density.

* * *

We are now at the end of our observations. I conclude with the firm conviction that the interest in Selenology will increase considerably and will in future time make rapid progress. I hand over these lines with the conscious feeling, of having given proof, that the groundwork of a useful Selenology must be founded on actual practical experience and look forward with every confidence to its further extension by more competent men.